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TRANSPORTATION SECTOR
PLANNING COMMITTEE REPORT

MAY 1989

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I. INTRODUCTION

The Science Council of British Columbia established a series of sectoral planning committees in early September 1987, based on its already existing AGAR grant committees, to identify opportunities for improving the application of science and technology to the economy of B.C. These committees comprise representatives of industry, universities and colleges, research institutions and government and are to develop specific sectoral plans for the application of science and technology. The recommendations of each committee will then be reviewed and priorities will be established by the Science Council and integrated into overall plans for science and technology by the Premier's Advisory Council on Science and Technology and by the provincial government.

The sectoral plans are aimed at identifying key strengths and weaknesses in order to make broad recommendations. Detailed investigations of specific opportunities or resolution of problems identified will occur once priorities have been established.

The Transportation Planning Committee has the objective to enhance research and development in this sector in order to improve the economic benefits of this sector to the province. For the purpose of this report, the industry has been taken to include:

- road and off-highway
- airline and aircraft
- rail
- marine
- logistics technologies
- pipelines have been excluded as they fit in the Energy sector
- general transportation items

The following were members of the Transportation Sector Planning Committee and their professional affiliations are:

Richard Pomeroy (Chairman)	DSL Dynamic Sciences Limited
Barrie Lindsay	Datel Communications Ltd.
Les Kerr	Conair Aviation Ltd.
A.R. Williams	World Transport Institute
Peter Shields	Shields Navigation Ltd.
Bob Cantwell	Canadian Airlines International
David Molyneux	National Research Council
Trevor Heaver	UBC Faculty of Commerce and Business Administration

II. EXECUTIVE SUMMARY

The Transportation Sector is a major factor in the Canadian and B.C. economy due to the geographic profile of the country and this province. The distances, difficult terrain and climate contribute to the vital importance of transportation.

This sector in B.C encompasses road and off-highway, airline and aircraft, rail, marine, logistics technologies, and general transportation. Each of these is discussed in the report and specific opportunities for economic development are identified.

Within Canada the major research and development activities involving transportation are conducted outside of B.C. These involve the Transportation Development Centre; National Research Council; CN; CP; Air Canada, and the universities.

B.C. is not currently a major factor in transportation research and development. U.B.C. has the major effort, but even there the total person years involved are small compared to Canada generally. A limited effort occurs at S.F.U. and at U.Vic. B.C. Research has some involvement in aerodynamics research, and marine research in conjunction with N.R.C. N.R.C. also has activity in tribology and in

the systems laboratory. B.C. Rail does some contract research and development.

A measure of the low level of transportation R & D is the fact that the Science Council of B.C. has nine peer review committees for applied research grants and does not include transportation specifically in any one. This is partly because the major transportation companies in Canada have headquarters outside of B.C. It will be necessary for B.C. to pursue niche opportunities in specific areas where activity can build on expertise that currently exists here. Many of these will require increased research and development effort to capitalize on the market opportunities.

These specific "niche" opportunities include in the road and off-highway group, the manufacture of off-highway vehicles, their maintenance systems; applications for robotics; and natural gas conversions. In addition, dispatch and communications systems are identified as priorities.

In the airline and aircraft sector, specialty aircraft conversion and manufacture, aircraft parts, repair and overhaul, and airline systems are identified.

In the rail area, traffic management systems and specialized equipment provide opportunities.

In the marine sector, the focus is on bulk terminals, ferries, regulations for coastal vessels, communications locators and undersea vehicles.

In the general transportation area, priority is given to weather systems, intermodal transportation, economic and geographic growth areas of B.C., recreation activities, safety and survival equipment.

In logistics technology, leadership is being shown in the introduction of an electronic data interchange facility. This technology and the potential for logistics services for Pacific Rim trade, form a basis for developments.

The committee feels strongly that a major effort will be needed to get the attention of all involved in the sector and raise their awareness of and interest in research and development. This will involve a major series of forums to look at each area and analyze its potential for R & D.

The priority focus indicated in the report will then be confirmed and communicated. Existing small and medium sized companies should be analyzed to determine their needs and assistance should be given to those successful B.C. enterprises. The funding available for

R & D should be communicated within the sector. In addition, market studies should be undertaken prior to R & D funding being committed.

It will be essential to coordinate this activity with other B.C. sectors and with national transportation efforts. The federal and provincial government's purchasing policies could impact significantly on this sector.

It is recommended that the planning committee should continue its role to spearhead the implementation of these recommendations.

III. BACKGROUND

In order to review the research and development activities in the broad transportation sector, the committee divided its review into the following areas:

1. Road and Off-Highway
2. Airline and aircraft
3. Rail
4. Marine
5. Logistics technologies
6. General transportation

1. ROAD AND OFF-HIGHWAY

A. Off-Highway

Consists of major trucking activity for the forest products industry, the mining industry, and the energy industry and is widely distributed geographically throughout the province and functions generally in difficult terrain. These industries represent major economic aspects of the provincial activity and the off-highway hauling aspect of their business is a very significant percentage of their activity.

B. On-Highway

Because of the large distances in the province there is a major activity in both intercity haulage of goods for consumption in the province and for the export of finished products from the major resource industries. There is also a major activity in delivery in the major cities in the province.

C. Highways and Bridges

Again a major sector of activity within the province but in the context of this strategic planning activity, it is being covered by the construction sector who are looking at the initial construction of highways and bridges and also the replacement of these in the general infrastructure replacement activity within the province.

D. Private Vehicles

As in any populated area, this is a major economic activity. It includes the purchase of vehicles, their parts, supply and repair, and the provision of gasoline, diesel, natural gas and also the development of alternative fuels to conventional gasoline and diesel.

E. Recreational Vehicles

A growing aspect of life in North America including the manufacture of trailers and motor homes.

F. Buses and Tour Buses

Based on the large geographic area of the province a major activity using bus transportation to move people and small parcels between cities and within cities. In addition, tourism is a major factor in the economy of B.C. and the large distances in B.C. mean a major role for tourist transportation.

G. Parcels, Courier Systems, etc.

A growing activity within the province is the delivery of parcels and courier systems and general mail systems.

H. Dispatch and Communication Systems

These have been a major economic activity in the province, again due to its geographic situation -- and have caused the development of an industry to produce products for this sector and export them on a world-wide basis.

2. AIRLINE AND AIRCRAFT

A. Airline and Helicopter Service

This sector includes the airline industry which consists of feeder services within the province for passengers and freight, and also the national and international airlines, some of which have their bases in this province. It also includes the charter air services and helicopter services for passengers, freight, and support of many of B.C.'s resource industries.

B. Aircraft Manufacture

This potentially includes float planes, fixed wing aircraft, and helicopters.

C. Specialized Air Applications

This includes airplanes adapted for fire fighting, spraying -- both on land and sea -- of various kinds and other specialty aircraft either manufactured or converted. An industry exists in this province now in this area. It also includes the adaptation of helicopters for specialized uses such as ambulance, spraying, long range flying, etc.

D. Manufacture of Airport Equipment

The province has a number of significant airports and smaller ones throughout the province and there potentially exists a market for the equipment for these airports as they are modified and constructed. Of particular significance is the equipment used for security purposes.

E. Manufacture of Aircraft Parts and Repair and Overhaul of Aircraft Parts

There is a small industry now in this activity which could be expanded significantly in the future, particularly for the specialty aircraft described in C above. Also, the potential exists for the manufacture of parts for the very large aircraft manufacturing industry located in Washington state and in Eastern Canada. Potential exists

for the development and manufacture of composite materials that could have application in a number of transportation areas.

F. Manufacture of Aircraft and Airline Supplies

Similarly, there exists the possibility to increase the manufacture of supplies for the aircraft and airline activities in the province.

G. Maintenance and Overhaul of Aircraft

An expanding activity exists in the maintenance and overhaul of aircraft, fixed wing and helicopters for B.C., Canadian and international organizations.

H. Development of Airline Systems

Based on the growing information technology sector in the province, there is the possibility of developing systems for the airline industry in terms of operational system scheduling, maintenance, and weather, etc.

I. Air Freight and Parcel Services

B.C. is a focal point for air freight and parcel services, both within the province, nationally and internationally.

J. Avionics

A developing industry is present in electronic systems for aircraft which has opportunity for growth.

3. RAIL

The major rail activities in the province consist of passenger and freightlines linking the province with the east through C.N./C.P. and VIA. Within B.C., B.C. Rail and some other specialized rail services are used for the transportation of raw materials and finished products. The activities involved with these are:

A. Manufacture of Rail and Rolling Stock for Railways

This is mostly manufactured within Eastern Canada and the U.S. and previous efforts to manufacture aspects of rail requirements within B.C. have not been successful to date. However, a renewed effort has recently occurred at the B.C. Rail plant in Squamish to assemble box-cars.

B. Supplies for the Railways

This includes rail, ties, tie plates, spikes, signal equipment etc; replacement parts and off track equipment.

C. Maintenance of Rail

Activity exists in the province in maintaining rail lines, beds and in testing different methods.

D. High Technology Systems and Equipment for Railways

These are again computerized and electronic systems where the province's skills can be applied and marketed on a world-wide basis. These include trip recorders and event recorders. The major Canadian railroads and consulting companies are presently involved in marketing rail expertise internationally.

E. Construction of the Railbed and Terminals

Engineering, design and construction expertise is important particularly tunnelling and difficult road bed conditions, snowsheds, slide protection, etc., for rail operations in the mountains. (B.C. has its own particular problems). The electrification of rail lines has received specific attention and will continue to be examined as environmental interests increase.

4. MARINE

The province has an extensive shoreline and much of its transportation activity revolves around marine transportation. British Columbia has the largest number of registered commercial vessels in Canada within the ferry, tug and fishing fleets [Canadian Total 40,988

ships (5,200, 816 GT) - B.C. 14,973 (1,644,500 GT) ref. TP 7923 List of Ships, Vol. 1, 1989].

Canada no longer has a large foreign-going commercial fleet, neither does the United States or other countries where high wages and superior working conditions are demanded.

A. Docks and Dock Systems

There are many docks throughout B.C. and the province has developed expertise in the design and construction of docks and dock systems which is exported.

B. Terminals

There is a need for passenger, freight, and bulk commodity terminals using the marine mode of transportation. Again, this has developed into an international engineering capability.

C. Tugs and Barges

There is a significant sector of the economic activity of the province that is served by tugs and barges moving bulk commodities throughout the coast.

D. Undersea Vehicles and Equipment

This has been a growing area of specialty in the province and an industry exists in the manufacture and design of undersea vehicles

and in the development and manufacture of undersea equipment for acoustics and signalling.

E. Fishing Vessels

There is a large fishing industry in the province and the construction and repair of its vessels is a significant industry.

F. Cruises, Ferries and Tourist Ships

The province has grown dramatically in the last few years in terms of the cruise ship activity using Vancouver and Victoria as base ports and serving the coastal and Alaska runs. In addition, a very large ferry system with a significant number of boats for both passenger and freight activity plays an important role in the Province.

G. Recreation

A large industry exists in the province involving the recreational aspects of boating. This includes fishing, sailing and power cruising. This industry includes the manufacture, repair, servicing, docking and supplying of this fleet and the marketing of design of recreational boats on a world-wide basis.

H. Propulsion, Navigation and Steering

Similar developments in the use of alternative fuels such as NGV for propulsion apply in marine activities as they do on land. In

addition, research and development in the design and manufacture of propellers and in steering and navigation systems has been undertaken in the province. The use of satellites for positioning and navigation has been developed.

I. Survival, Safety, and Rescue

A significant activity exists in B.C. in lighthouses, coastguard, air/sea rescue, weather forecasting, communications, tide and wind forecasting. Manufacturers of rescue boats, inflatable lifesaving devices, marine evacuation systems and survival clothing have established substantial export markets. Survival techniques, training and various aspects of fishing vessel and pleasure boat safety command international attention as products of the vital marine industry in B.C.

J. Marine Electronics, Naval Architects and Coatings

B.C. has developed expertise in marine electronics, naval architecture, and coatings which are being utilized on a world-wide basis.

5. LOGISTICS TECHNOLOGIES

Logistics is increasingly being recognized as the necessary management framework to plan and control functions aimed at bringing materials from primary sources through all intermediate manufacturing

steps to the end users. In this sense, logistics includes transportation, handling, storage and all related communications processes. Integrating the management of the various activities is becoming central to the competitive status of goods and to the design and marketing of transportation services. As such, it is a potentially important area for research activities and utilizes the systems and modeling skills developed in the province.

A. Warehousing, Distributing and Storage

This is a major aspect of a province with geographically diverse population centres and major trading activities. It involves the sorting of goods, movement within the province by air, road, rail and sea and then distribution to end points.

B. Cargo Handling

Systems for the movement of cargo on and off marine and air systems to storage and to land transportation is a growing area of activity.

C. Intermodal Transportation

Because of the nature of the geography of the province, goods move from one mode of transportation to another and the linkages and interaction required for these activities is an area for research and

development. This includes the materials handling and people moving systems required.

D. Communications Systems

The movement of goods requires the transfer of information among many parties especially those involved in international trade. The substantial documentation involved gives rise to opportunities for cost savings and service improvements through the use of developing communications technology.

6. GENERAL

There are a number of transportation related activities that flow across all of these sectors:

- A. Weather systems for all modes of transportation.
- B. Transportation needs of economic and geographic growth areas of B.C.
- C. Interaction with other sectors. There is a clear interaction of transportation needs and activities with the manufacturing sector, the energy sector, the information technology sector and advanced materials.
- D. A recognition that there are companies and individuals working in the province with a proven track record in transportation activities and these should be recognized and expanded.

- E. Survival equipment used in air and marine activities and for extreme cold weather land activities.
- F. Environmental concerns including the resulting pollution from transportation itself and the transport of hazardous cargo.
- G. Fuel management systems are an important area for all modes of transportation.
- H. Innovation in various areas in support of transportation.

IV. TRANSPORTATION RESEARCH IN CANADA

The transportation research activities within Canada are discussed under the following headings:

1. Transportation Development Centre (TDC);
2. National Research Council
3. The Canadian Universities
4. The major transportation organizations in the country --
C.N., C.P., Air Canada, Canadian Airlines.
5. Canadian Attitudes Towards Transportation Opportunities

1. TRANSPORTATION DEVELOPMENT CENTRE (TDC)

This is located in Montreal, Quebec, has a staff of 25 professional engineers and transportation planners and basically contracts out its R & D program. In 1986/87 it was involved in 320 R & D projects with a total value of \$16.8 million. These projects were mainly involved with improving the safety and efficiency of transportation in Canada. It was established in 1970 by Transport Canada to provide research support to the other components of the department by managing an R & D program that would depend on industry to carry out research on a wide range of projects related to air, marine, rail, highway, and urban transport. The resulting developments of the TDC ensured that Canadian companies have become world leaders in

a number of transportation areas and have been able to compete at the international forefront of many others. TDC projects are funded by a variety of sources including Transport Canada; special funding programs such as the unsolicited proposals program, other federal departments whose interests include aspects of transportation, provincial departments, and national associations. In 1986/87 the Centres own R & D budget was levered 3 times from these outside sources.

2. NATIONAL RESEARCH COUNCIL

Transportation research has been a major aspect of NRC's programs and it functions out of a number of facilities in the country:

1. The Institute for Marine Dynamics in St. Johns, Newfoundland with two components, the hydrodynamic research station which undertook a program in 1987/88 of 35 person years, and the arctic vessel research section with a 25 person year program in the same year.
2. The National Aeronautic Establishment in Ottawa with a low speed aerodynamics laboratory of 14 person years, a high speed aerodynamics laboratory with 48 person years, a steady aerodynamics laboratory with 10 person years; a flight research laboratory with 32 person years and a structures and materials laboratory with 46 person years.

3. Mechanical Engineering in Ottawa with an engine laboratory of 19 person years, a fuels and lubricants laboratory of 14 person years, a gas dynamics laboratory of 21 person years, a low temperature laboratory of 34 person years, a vehicle dynamics laboratory of 18 person years, a systems laboratory of 12 person years and a tribology and mechanics laboratory of 4 person years in Vancouver, B.C.

3. RESEARCH ACTIVITIES AT CANADIAN UNIVERSITIES

Six transportation centres are maintained at Canadian universities: The University of British Columbia, The University of Manitoba, York University and The University of Toronto, Queen's University, Le Universitaire de Montreal, and Dalhousie University. The centres have different specializations, including transportation economics and management, rail technology and systems modelling. Engineering departments at some universities are well known for their work on transportation structures and vehicle technology. These technology and science oriented program are supported through NSERC funding for transportation research.

4. MAJOR CANADIAN TRANSPORTATION ORGANIZATIONS

Organized research and development activities are undertaken by CN, CP, Air Canada, and Canadian Airlines for their own particular interest throughout the country. Nothing was identified for on-road, off-road and marine sectors.

C.N. Rail

C.N. Rail's R & D staff consists of 80 full time employees. They are employed in C.N.'s own R & D facility on Cote de Liesse Rd., Montreal. This is a fairly modern facility and is located adjacent to C.N.'s Montreal freight car classification yard. C.N.'s budget for R & D in 1987 was \$5.7 million.

In house projects include the usual railway problems and suggested solutions:

- rail wear
- track-train dynamics
- wheel wear, which has led to wheel profiling
- hunting trucks, to minimize wheel and curvature wear
- concrete ties, tie pads and anchors.

C.N. works closely with the Association of American Railroads who carry out a large R & D program, including the use of a test track at Pueblo, Colorado. On occasion outside consultants are also used.

C.P. Rail

C.P. Rail has 30 full time employees in R & D working in Montreal. Some R & D work has been carried out in the past few years at Calgary in connection with the building of the Selkirk Tunnel.

The budget for 1987 was \$3.5 million. C.P. uses outside consultants for projects when the in-house expertise or necessary testing equipment is lacking.

Both C.N. and C.P. R & D do in-house testing for their Purchasing & Materials Departments. As in the case of C.N. Rail, C.P. works closely with the A.A.R. R & D section. Both major railways also work closely with Transport Research (Canada).

AIRLINES

Both Canadian Airlines and Air Canada have their research activities spread throughout their operations with no central R & D departments. Due to the high technology nature of their business and the extensive government regulation involved most R & D is done by aircraft and parts manufacturers.

5. CANADIAN ATTITUDES TOWARDS TRANSPORTATION OPPORTUNITIES

A report entitled "Canadian Transportation Microelectronics Opportunities and Capabilities: Real or Imaginary?" was reviewed*.

*NOTE: Thomas E. Clarke, Author

This report, supplementing an earlier literature survey, deals with transportation under six modes - LAND, AIR, RAILWAY, URBAN MASS TRANSIT, MARINE, PIPELINE.

The report analyzes opportunities for the application of microelectronic technologies to transportation. It identifies challenges which must be overcome and, particularly comments on impediments to Canadian industry participation in the Canadian and foreign markets.

The study shows that opportunities for Canadian-owned micro-electronics transportation firms are limited to small, specific market niches involving mainly equipment and sub-systems. Large foreign multi-nationals, where they exist, are experienced and effective but smaller Canadian companies lack the depth and commercial experience to support their generally high level of technical competence.

The major reason put forth why Canadian companies exhibit weakness is the conservative, risk averse buying practices of Canadian government departments and Crown Corporations. By showing preference for existing products which are almost inevitably imported, these purchasers are denying smaller Canadian companies the opportunity to learn, grow and become competitive not only at the domestic but also the world level.

In addition to the general difficulty just stated, companies concerned with each of the six modes cited other specific problems:

LAND: - Canadians are unwilling to try new things, particularly if developed and manufactured in Canada.

- Smaller firms lack marketing skills.

AIR: - Selling to Canadian government agencies is difficult.

- Canadian approvals are difficult due to strict regulations.

- Smaller firms lack marketing skills.

RAIL: - Buying policies of railroads are conservative.

- Canadian buyers show strong preference for dealing with large companies, lack faith in Canadian products.

TRANSIT:- Sales in the USA are hindered by the buy-America policy.

- Extreme price competition favours the large established firms.

- Conservative buying practices and onerous guarantee requirements in Canada discourage smaller firms.

MARINE: - The Canadian market is small and Canadian buyers are conservative.

- There is a lack of support by government bodies such as DOT, DOC, and DRIE for smaller companies.

PIPELINE: This sector was an exception to the other five in many respects.

- Canadian companies have established a very successful track record in this sector.

- Firms experience a bias toward buy-Canadian.
- Buy-America policies and difficulties at Canadian customs were cited as impediments to exporting into the USA.

Recommendations of the report are mainly toward more organized and active support to Canadian companies from universities, government R & D programs, government laboratories and other agencies supporting Canadian technological advancement. In addition, large institutional purchasers are urged to support national industries through buy-Canadian policies.

V. TRANSPORTATION RESEARCH IN BRITISH COLUMBIA

Transportation research and development in B.C. is discussed under the following headings:

1. University of B.C.
2. B.C. Research
3. Simon Fraser University
4. University of Victoria
5. N.R.C. in B.C.
6. B.C. Rail
7. The Marine Industry
8. The Aerospace Industry
9. The Airline Industry
10. Consulting Engineering Organizations
11. Level of Interest in Transportation R & D in B.C.

1. TRANSPORTATION RESEARCH AT THE UNIVERSITY OF BRITISH COLUMBIA

Transportation and Logistics Research in the Faculty of Commerce and Business Administration

A number of faculty members are involved in various aspects of transportation and logistics research. Six faculty members are involved; G. Chow, T.D. Heaver, T.H. Oum, M.W. Tretheway, D.H. Uyeno

and W.G. Waters. Research ranges from studies of national policy issues, management decisions affecting the use of infrastructure (for example, Vancouver and Toronto Airport) and methods to improve systems performance, (for example, ship and rail interface in the Port of Vancouver) and ambulance location analysis.

Transport Research in Applied Science

There are three departments in Applied Science which do transport research; they are Civil Engineering, Electrical Engineering and Mechanical Engineering.

Faculty in Civil Engineering are involved in various aspects of transport related work. They include: G. Brown, accident related work involving accident reconstruction and traffic conflict analysis. F. Navin, accident reconstruction and truck stability (roll-over characteristics). There are a number of faculty involved in various aspects of "traditional" highway engineering, for example, R.G. Campanella (slope stability), R.J. Gray (highway materials engineering), R.F. Hooley (bridges), S. Mindess (materials, e.g. concrete) and A. Russell and S.O. Russell (construction management and decision analyses).

In the Department of Electrical Engineering, no transport related research seems to be going on at the present time. A few years

ago, graduate students in the department were active and effective in the design of electrical vehicles in the context of North American universities competition.

In the Department of Mechanical Engineering, Professors H. Vaughan and S.M. Calisal are active in marine research, particularly as it relates to aspects of vessel stability. Professor P.G. Hill is involved in research on the internal combustion engine. Professor V.J. Modi is doing work on the aerodynamic efficiency of truck designs (he has recently received local publicity for this work) and Professor G.V. Parkinson has been involved in aerodynamic research related to wing design.

In addition, Professor A.E. Hall of the Department of Mining and Mineral Process Engineering does work related to the on-site transportation of mining products.

2. TRANSPORTATION RESEARCH AT B.C. RESEARCH

In the marine and aerodynamic research areas, the laboratory capabilities of B.C. Research are important resources upon which to base research activities. In addition B.C. Research is involved with Transportation Research, Materials Handling, Oceanography, Dual Fuel Engines, etc.

3. TRANSPORTATION RESEARCH AT SIMON FRASER UNIVERSITY

Dr. Tad McGeer working as a member of the Intelligent Systems Research Group in the Centre for Systems Science at Simon Fraser University and as part of the Advanced Systems Institute of B.C. is working on a joint project, YAMA, with International Submarine Engineering.

This project is working towards autonomous and flexible machines that will move both indoors and outdoors, while avoiding stationery and moving obstacles and recognizing a limited repertoire of objects. The research encompasses bipedal walking and running, to allow travel on stairs and rough terrain, vision-based navigation, so that the machine can detect footholds, free paths, and obstacles, task planning, so that this information can be used by the machine to check its way to a goal; one object recognition, so that the robot can do something useful when it arrives at the goal.

4. TRANSPORTATION RESEARCH AT THE UNIVERSITY OF VICTORIA

Dr. Tom Lambe is undertaking research in the School of Public Administration. The object is to gain an understanding of policy and operating decisions with particular regard to urban transportation. General areas of research are public transit, capital investment, and consumer choice. To provide sources of data and knowledge of current problems, contact has been established with relevant private and public

agencies such as the Traffic Engineering Departments of the cities of Vancouver and Victoria, the Planning Department of the Capital Regional District (Victoria), and the Ministry of Highways (B.C.).

The topics of immediate interest are:

- 1) the development and testing of a mathematical model for the behaviour of automobile flow in city streets.
- 2) the interface between the information base and engineering decision-making with regard to urban parking and traffic management.

In addition, Dr. Vickers is working closely with industry to develop further applications for the use of CAD/CAM in the ship building sector.

5. TRANSPORTATION RESEARCH AT NRC IN VANCOUVER

There are two areas with transport components at NRC. The first is a part of the Tribology and Mechanics Lab. The second is the Systems Lab which itself is a part of their Computer Technology Field.

Tribology deals with the science of friction, lubrication and wear. NRC has been involved in rail and wheel wear research for about ten years. The research has contributed to new methods of maintaining rail. They have worked recently on the noise problem of Skytrain and

on bearing problems of B.C. Rail. Research in 1987 involved some \$40,000 of operating and capital expenditures and about three and a half person years. In addition, TDC funding of \$25,000 was involved. Members of the group teach Tribology in the UBC Department of Mechanical Engineering.

Work in the Systems Lab is under the general Resource Industry Application of Projects. Work has been done on transportation related to the grain and mining industries. Work during the last year has involved about two man years of commitment.

6. B.C. RAIL

B.C. Rail does not have a full time R & D staff and consequently does not have a separate R & D budget. R & D work is carried out as required by the use of personnel in the department(s) concerned. The bulk of the R & D work being carried out by the Engineering Department. For the testing of materials B.C. Rail uses mainly outside laboratories and consultants.

B.C. Rail has been working with NRC laboratories in Ottawa and Vancouver concerning its Tumbler Ridge line. This work concerns:

- Track wear
- Track curvature
- Wheel wear
- Wheel profiles

They are working with Dr. J. Kalousek and also C.P. Rail on questions concerning rail metallurgy and its relation to wear in curves. In this cooperative research program, B.C. Rail is providing a grinding train for the field tests, which are evaluated at the NRC laboratory. Dr. Kalousek also carries out laboratory research programs into wheel wear and wheel profiles.

B.C. Rail also works closely with C.N. and C.P. on tests and investigations of problems of mutual interest. There is good cooperation amongst these railways and others in the industry. Details of projects and test results are usually shared with any interested railway.

As it does not have its own R & D staff B.C. Rail uses outside consultants on major projects as required.

7. RESEARCH AND DEVELOPMENT FOR THE MARINE INDUSTRY

Tugs and Barge

Currently there are no R & D departments in the major companies involved in the tug and barge activity in the province. However, there are funds available through the Transportation Development Centre for

consultant projects. These include:

- development of systems for precision radar and integrated navigation systems for coastal inland navigation;
- the development of a high-speed high-resolution colour graphic shift board integrated navigation and display system;
- the development of low resistance barge hull forms;
- the development of technologies utilized on marine vehicles capable of year round Artic operation;
- the development and testing of a family of energy efficient components and systems connected with stable towing, low resistance barge forms;
- the evaluation and testing of steering configurations for barges.

Undersea Vehicles and Equipment

Significant activity is underway in B.C. in developing undersea vehicles and equipment.

8. BRITISH COLUMBIA AEROSPACE INDUSTRY

A report produced in September 1987 by the B.C. Aviation Council's Aerospace Task Force indicates that, the Canadian Aerospace Industry has 200 firms employing 50,000 people with annual sales approaching \$5 billion with 70% of its products exported. The B.C.

Aerospace Industry, however, is much smaller with only 7 firms with annual revenues in excess of \$3 million and total revenue in 1986 of \$77 million and employing 950 people.

Problems identified by the B.C. Aerospace industry relate to its small size and external forces such as government regulations including customs clearances, government tax legislation and product liability insurance. This report also recommends a number of initiatives related to research and development.

In the short term it supports the concept of building on existing companies and individuals who are in the market place and supporting them in the medium term by:

- trying to remove some of the customs problems
- ensuring that the necessary training facilities and infrastructure programs are in place;
- trying to resolve the product liability insurance problem
- acquiring the rights to manufacture replacement parts for out-of-production aircraft;
- establishing liaisons with subcontractors;
- trying to do subcontract work on aircraft produced in eastern Canada.

In the long term it advocates the development of a world-class transport aircraft repair and overhaul centre:

- acquiring rights, jigs and tooling to manufacture aircraft which are no longer in production;
- developing advanced composite materials, ceramics and high technology and metal alloys;
- building a strong technical base which focusses on software and engineering applications.

These are areas that this committee supports for research and development.

9. AIRLINE RESEARCH AND DEVELOPMENT

Canadian Airlines

While small pockets of research and development do exist throughout the organization, no formal research and development budget exists and most research on aircraft related parts or systems is done by the manufacturers.

An estimated \$1 million is spent in B.C. on operations research, informations systems research, and ad hoc projects in engineering and maintenance.

Due to the high technology nature of the business, large sums of money are spent on development and implementation of leading edge systems that do not qualify as research.

Conair

Undertakes some research and development into modification to aircraft and into composite materials.

Air Canada

The headquarters and operations base for Air Canada are in Eastern Canada and no formal research and development work is done in B.C.

Canadian Helicopters

Undertakes research and development or modifications to helicopters for ambulance, fire fighting and long distance operations.

TDC - Air Technology

Of the \$3.3 million listed as 1987 projects, only 1.75% was performed by B.C. companies.

10. CONSULTING ENGINEERING ORGANIZATIONS

A significant number of B.C. consulting engineering companies are involved in transportation research on a world-wide basis. This covers rock and slope studies, tunneling, terminals and systems.

11. LEVEL OF INTEREST IN TRANSPORTATION RESEARCH IN BRITISH COLUMBIA

The transportation sector of the B.C. economy is large due to the size of the province and its physical and climatic profile. However, the research and development activity has been very small.

There has not been a high level of interest and activity in transportation research and development in British Columbia in the past. This is evidenced by the absence of any major transportation research laboratories or facilities in this province serving national requirements and by the relatively small aspects of the three universities' activities that relate to transportation. Also, by the absence of many major private sector or government organizations focussing on transportation research and development.

There have not been enough proposals in this sector to command a regular and ongoing part of the Science Council of B.C.'s funding for research and development through its AGAR program. For the past eight years approximately \$3.5 million has been available annually for applied research in the various sectors in the province.

This low level of activity in transportation research and development partly results from the fact that many of the participants in the large transportation sector in this province have their head offices and research activities in the east, namely C.N., C.P., Air Canada, and Transport Canada. There is also no major manufacturing

activity in many of the basic transportation areas. The manufacture of private automobiles is not conducted here, nor of railway locomotives or rolling stock, nor of major aircraft. There is currently a renewal of the rail car manufacture activity at Squamish.

It will be necessary for B.C. to pursue specialized niches in this sector in order to carve out pieces for B.C. economic development. These niches will be based on natural advantages and the presence of expertise and experience.

VI. PRIORITY AREAS FOR RESEARCH AND DEVELOPMENT IN B.C.

The committee reviewed all of the activities in transportation in British Columbia. It has then prioritized those areas that it believes could warrant research and development activity conducted in the province. It has based this prioritization on the potential market opportunities for those sectors, firstly to satisfy the specialized user needs in the province and subsequently on a world-wide basis, combined with a present expertise and experience in that sector on which to capitalize. Therefore, it is felt that these combinations of market opportunity and existing capability could warrant research and development activity in order to build and sustain these sectors and in order for them to have significant impact on the provincial economy. Within each of the sectors described earlier, the priorities are as follows:

1. ON-HIGHWAY AND OFF-HIGHWAY

The priorities here are:

- a) the manufacture and modification of on-highway and off-highway vehicles;
- b) maintenance systems for on-highway and off-highway vehicles;
- c) the application of robotics to the operations of off-highway vehicles;

- d) the possibility of developing natural gas conversions for on-highway and off-highway vehicles which is presently being pursued by the energy sector;
- e) dispatch and communications systems -- this area links into the information technology sector and its focus on wireless communications and is a large sector of the provincial economy and provides a solid base on which to develop further applications in the dispatch and communications of transportation vehicles.

2. AIRLINE AND AIRCRAFT

The priorities here are:

- a) Specialty aircraft and helicopter applications for fire-fighting and spraying where a thriving world-wide export industry exists through local companies and where further research and development is needed to expand market opportunities.
- b) Manufacture, remanufacture, maintenance and overhaul of aircraft and helicopters and their parts, particularly identified here are the development of composite materials and the availability of premium casting and fabrication of metals that could be used in a number of applications for aircraft. This would build on the advanced materials capability in the province and its application to the existing specialty aircraft conversion activity and the potential for

the manufacture of aircraft parts for the very large market in Seattle through Boeing aircraft.

c) Development of aviation systems - The province has a growing information technology area including major systems development companies and smaller electronic companies all of which are growing at 25% per year and it is felt that an opportunity exists through this sector interaction with airline systems for maintenance, operations, scheduling, event recorders for smaller aircraft, and automated air traffic control systems.

d) Avionics

The province has a growing electronics industry and many opportunities exist to focus on avionics aspects of this area.

3. RAIL

Two areas of priority exist, systems and equipment.

Requirements and specifications for a new, computer-based traffic management system are currently being developed by the railroad industry. This provides opportunities for companies active in computer dispatch systems. The high safety and reliability demands of the railroad industry place a heavy burden on development resources and will tend to restrict this opportunity to the larger and more experienced companies.

Individual items of equipment, however, present a significantly different opportunity. Although demands for performance, reliability and robustness are high the standards can be met by a much broader spectrum of companies. Equipment linked to the Advanced Train Control System will, if successfully utilized in the initial systems, tend to be used in future systems both in North America and abroad. Hence, a wide market participation would evolve. Equipment is primarily electronic but some is mechanical.

In addition snow and rock slide detection equipment and devices for safe rail operations could be developed here for world-wide sale.

4. MARINE

Priorities here emphasize the particular nature of marine activity in the province:

- a) Bulk commodity terminals which have been developed and engineered world-wide from British Columbia.
- b) The ferries, one of the world's largest ferry fleets exists in this province and R & D related to that system can be pursued.
- c) Regulations for coastal vessels. The application of R & D is restricted through the regulations applying to tugs and barges and fishing vessels in the province and some review of these regulations and their adaptation to these particular types of marine transportation is warranted. This in turn would allow further R & D into the actual design and manufacture of these vessels.

d) Communications locaters for marine vessels including cruise ships is a possible area.

e) Undersea vehicles. This area has received priority attention in the past and continues to offer opportunities for world-wide economic development.

5. LOGISTICS

Research and development is currently underway in the introduction of an electronic data interchange facility. This will form the basis for further developments. In addition, developments are possible in warehousing and distribution, intermodal systems, and communications systems.

6. GENERAL

a) Weather systems for all modes of transport and current forecasts for marine use. Weather plays a large part in the transportation activities in all modes throughout the province and systems to improve weather forecasting and communication of weather data are potential areas for R & D activity within the province.

b) Intermodal transportation. Because of the nature of the geographic activities within the province goods and people move from one mode of transportation to another and the linkages and interaction and documentation required for these activities is an area for R & D and development.

c) Transportation needs of growth areas of the B.C. economy. The possibility exists that transportation R & D activities could focus on the growing geographic and economic areas of the province particularly as many of these are in remote areas where innovative entry methods will be required.

e) Recreation. A very large sector of the B.C. economy which could warrant some R & D activity and similarly included in this the cruise ship and ferry activity. Also the airline area is a growth area within the province that could warrant activity.

f) Survival and safety equipment. This important area involves specialized boats, clothing and communications systems where expertise now exists to build national and international market strength.

g) Environmental. Due to the difficult terrain and climatic conditions, environmental concerns of pollution and the transportation of hazardous cargo must be addressed. These could include warning systems, clean up, and reduction of pollutants.

VII. WAYS TO INCREASE R & D ACTIVITY IN THE TRANSPORTATION
SECTOR IN B.C.

As indicated in this report, the transportation sector is a very large part of the B.C. economy. To date, it has not been a major area for research and development within British Columbia and in fact B.C. has not experienced the percentage of national R & D related to its share of national transportation expenditures. However, the committee believes that an effort should be made to try and build this R & D activity in the province so that large economic opportunities possible through improved transportation can be identified and the costs of transportation can be kept as low as possible in terms of their impact on other economic activities in the province. The Committee believes that efforts are required in the following areas to increase the R & D activity in transportation in B.C.:

1. Increase the awareness of the usefulness of R & D potential within the transportation sector in B.C.
2. Provide a focus for this R & D activity on the priorities indicated earlier.
3. Place a priority on supporting existing companies and individuals with success in transportation activities in B.C.
4. Proactively increase the funding and the awareness of funding for research and development in B.C. so that the niche areas identified can be exploited.

5. Support market studies for potential R & D activities in transportation research.

6. Support the interaction of B.C. organizations with national and international R & D activities in transportation.

7. Encourage provincial and federal government support for transportation R & D through their purchasing policies and risk reduction programs.

8. Continue a focus on transportation R & D in B.C. through the sector planning committee and its support resources.

9. Plan for the people requirements of the transportation sector through education and training programs so that required researchers, receptors and manufacturers are available.

1. Increase the Awareness

A major effort will be required to contact all of those industrial and government personnel in the province with an interest in transportation and present sufficient information to them to awaken their interest in R & D activities in transportation in the province. This will require an initial overall seminar with enough interest to attract those involved and then subsequent meetings of the sectors outlined above, namely:

- on-highway and off-highway truck
- airline and aircraft
- railway
- marine

- logistics
- overall transportation systems

These specialized meetings would focus on the suggested priorities to reach agreement within each sector that these are the priorities and develop action plans for building research and development programs that will focus on the problems identified in each sector of the industry and developing innovative solutions.

2. Provide Priority Focus

The priorities suggested in this report and confirmed by the sector forum and subsequent meetings should be communicated to the provincial government and industry and maintained as a focus.

3. Supporting Existing Companies and Individuals

Specific discussion should be held with the companies that are now involved with transportation activities within the province. An inventory of these should be developed including those people undertaking research and development involving transportation and specific programs should be identified that could assist these companies to grow and expand. There are only a limited number of them and the amount of support needed to build them and grow them would not be major in relation to the potential economic impact.

4. Funding for Research

An inventory of those funds available for transportation R & D within British Columbia should be made and communicated to all of those involved at the meetings suggested earlier and specific effort should be made to broaden this funding including the possibility of NSERC university chairs related to transportation at the universities and an appropriate B.C. share of national funds for transportation research

5. Market Studies

Funding is available through the Science Council for initial market studies for potential products and services prior to embarking on the research grant programs and these should be utilized to research potential transportation products and systems prior to their research and development.

6. Tie-In to National Organizations

Because of the nature of the transportation industry in the province, it will be necessary for those involved in transportation research to continue to coordinate their activities with national organizations and some funding and support may be necessary to enable these activities to occur.

7. Government Policies

The impact of transportation costs and services on the provincial economy is significant and the provincial government through its purchasing policies and potential risk reduction programs can encourage B.C. companies to develop products that can be sold provincially initially and then nationally and internationally.

8. POTENTIAL ON-GOING ROLE OF THE PLANNING COMMITTEE

In order to pull together those interested in research and development in transportation this committee could provide the initial focus for information on transportation research and development within the province and its potential opportunities and could lead the implementation activity recommended in this report.

9. PEOPLE PLAN

Develop a manpower plan outlining people requirements in the future, ensure education and training are available to satisfy needs for researchers, manufacturers, and receptors for advanced technology.



SUMMARY OF RECOMMENDATIONS

FROM ALL SECTORS

AGRICULTURE AND FOOD PROCESSING

PRIMARY AGRICULTURE

- ROLE OF AGRICULTURE CANADA
- VERY SMALL AVAILABLE LAND BASE

SECONDARY MANUFACTURE

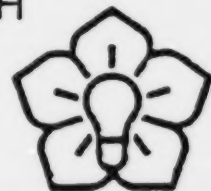
- POTENTIAL GROWTH AREA

FOOD PROCESSING

- POTENTIAL GROWTH AREA

RECOMMENDATIONS

- INTERFACE WITH BIOTECHNOLOGY
 - DISEASE CONTROL
 - GENETICS
 - WASTE MANAGEMENT
- VALUE ADDED
 - FOOD PROCESSING
- INCREASE PRODUCTIVITY
- INCREASE INDUSTRY INVOLVEMENT
 - CO-OPERATIVE RESEARCH



AGRICULTURE AND FOOD PROCESSING

RECOMMENDATIONS (CONT'D.)

- FUNDING FOR SECONDARY MANUFACTURE,
FOOD PROCESSING
- RESEARCH ORGANIZATIONS STAFFING AND
EQUIPMENT
- GENERAL AWARENESS
- TECHNOLOGY TRANSFER

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AQUATIC RESOURCES

\$750M INDUSTRY

AQUACULTURE - HIGH GROWTH
- SCIENCE ISSUES

RECOMMENDATIONS

- WATER QUALITY
 - SPECIFIC CONTAMINANTS
 - AQUACULTURE
- AQUATIC INSTRUMENTS AND DEVICES
 - INTERFACE WITH SECTOR
 - GROWTH AREA
- FISH HARVESTING
 - GOVERNMENT AND SOCIAL POLICIES
 - IMPROVEMENTS POSSIBLE
 - SHIP/SHORE COMMUNICATION



AQUATIC RESOURCES

RECOMMENDATIONS (CONT'D.)

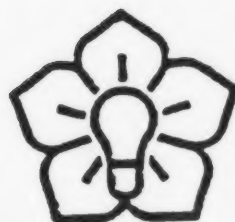
- FISH PROCESSING

- NEW PRODUCTS
- BY-PRODUCTS
- QUALITY
- PACKAGING

- AQUACULTURE

- INTERFACE WITH BIOTECHNOLOGY
 - DISEASE CONTROL
 - NUTRITION
 - GENETICS
 - WASTE MANAGEMENT
- NETWORK OF EXCELLENCE

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BIOTECHNOLOGY

EMERGING INDUSTRY - \$12M

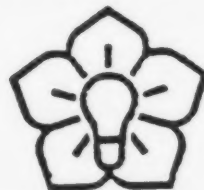
IMPACTS ON MANY SECTORS - FORESTS

- AGRICULTURE
- AQUACULTURE
- HEALTH
- WASTE MANAGEMENT
- MINING

NEED FOR STRATEGIC PLANNING, CO-ORDINATION

RECOMMENDATIONS

- FOCUS ON
 - DISEASE CONTROL
 - GENETIC IMPROVEMENT
 - WASTE MANAGEMENT
- STRATEGIC PLANNING - USE OF EXISTING COMMITTEE
- LONG TERM COMMITMENT OF FUNDING
- RAISE FUNDING FROM \$10M TO \$30M - 5-10 YEARS

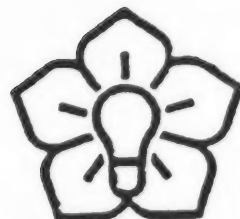


BIOTECHNOLOGY

RECOMMENDATIONS (CONT'D.)

- STRATEGIC RESEARCH, TRAINING, SCHOLARSHIPS
- INDUSTRY/UNIVERSITIES INTERACTION
- REVIEW FACILITIES NEEDS AND CO-ORDINATION

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ENERGY

MAJOR RESOURCE OF PROVINCE

DEPENDENCE OF OTHER RESOURCE SECTORS

OIL - IMPORT TO B.C.

NATURAL GAS SURPLUS

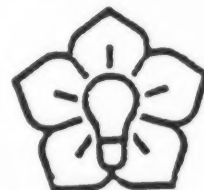
RECOMMENDATIONS

- OIL & GAS

- DEVELOP UNDERSEA ROBOTICS
- PREPARE FOR SWITCH AWAY FROM OIL
- NATURAL GAS DIESEL ENGINE CONVERSION

- COAL

- DEVELOP CAPABILITY TO ANALYZE COALS
- BENEFICIATION & TRANSPORTATION
- ALTERNATIVE USES



ENERGY

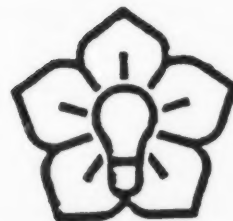
RECOMMENDATIONS (CONT'D.)

- WOOD RESIDUE AND BIOMASS
 - CONTINUE DEVELOPMENTS -
METHANOL, ETHANOL
- OTHERS
 - HYDROGEN
 - FUEL CELL

SCIENCE & TECHNOLOGY ENERGY FOCUS

- CENTRE FOR ENERGY STUDIES
- BUILD EXPERTISE
- UNDERTAKE TESTS
- NATURAL GAS
- LONGER TERM ITEMS

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FORESTS AND FOREST PRODUCTS

GROWTH AREA

MOVING TO VALUE ADDED PRODUCTS

RESOURCE DIMINISHING AND MORE EXPENSIVE

WORLD-WIDE COMPETITION

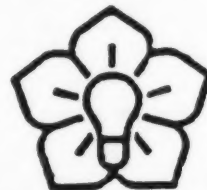
DEPENDENCE ON SCIENCE & TECHNOLOGY

ADVANCED MACHINERY AND SYSTEMS

PEOPLE NEEDS

RECOMMENDATIONS

- OVERALL CO-ORDINATION FOR SCIENCE AND TECHNOLOGY
- ADD VALUE
- IMPROVE PRODUCTION FOR RESOURCE

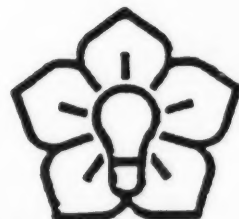


FORESTS AND FOREST PRODUCTS

RECOMMENDATIONS (CONT'D.)

- RAISE TECHNOLOGICAL AWARENESS AND COMPETENCE
 - RESEARCHERS
 - 'RECEPTORS'
- TECHNOLOGY TRANSFER
- USE OF ADVANCED SYSTEMS, TECHNOLOGIES AND MACHINERY

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INFORMATION TECHNOLOGY

\$1 BILLION INDUSTRY

11,500 PEOPLE

25%-50% ANNUAL GROWTH

RESOURCE INDUSTRIES/INFORMATION TECHNOLOGY

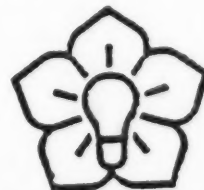
PEOPLE NEEDS

CO-ORDINATED ACTIONS

RECOMMENDATIONS

- ENHANCE RESOURCE INDUSTRIES BY
ENHANCING THE INFORMATION TECHNOLOGY
INDUSTRIES
- COMMIT TO INFORMATION TECHNOLOGY
- MARKETING, MANAGEMENT, TECHNICAL
PEOPLE
- CO-ORDINATION AND PLANNING ROLE
- INFRASTRUCTURE AND SUPPORT

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MANUFACTURING

IMPORTANCE TO PROVINCE

4,000 COMPANIES - 40 LARGE

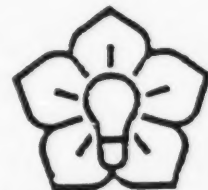
LACK OF TRAINING

DIFFICULTIES OF LOCATING PARTNERS

TECHNOLOGY TRANSFER - SMALL COMPANIES

RECOMMENDATIONS

- STRATEGIC PLAN - 'CHAMPION'
- BIOMEDICAL DEVICES
- EDUCATION AND TRAINING
- TECHNOLOGY CENTRE
- RESOURCE INDUSTRIES - ROBOTICS
- NETWORKING
- CAD/CAM
- FUNDING



MINING, MINERALS, METALS

NEEDS

- INDUSTRY INVOLVEMENT
- NATIONAL CO-ORDINATION
- FOCUS ON R&D
- RAISING AWARENESS

RECOMMENDATIONS

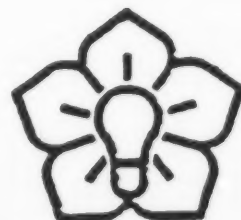
- R&D CO-ORDINATOR FOCUSSED ON B.C. NEEDS, NATIONAL INTERFACE
- INDUSTRY CHAIRS - ADVANCED MATERIALS
- CENTRES OF EXCELLENCE:
 - ADVANCED MATERIALS
 - INDUSTRIAL MINERALS
 - GEOLOGICAL EXPLORATION
 - RARE & PRECIOUS METALS



EMERGING THEMES

- BUILD ON EXISTING COMPANIES, ORGANIZATIONS AND INDIVIDUALS
- ORGANIZED STIMULATION OF INTERACTION AND PLANNING WITHIN AND BETWEEN SECTORS
- RESOURCE INDUSTRY FOCUSSED, TECHNOLOGY DRIVEN CENTRES OF EXCELLENCE
- VALUE ADDED PRODUCTS FROM RESOURCES USING TECHNOLOGY DEVELOPED IN B.C.
- DEVELOP THE MARKETING, MANAGEMENT AND TECHNICAL TALENTS OF OUR PEOPLE
- EFFECTIVE USE OF SIGNIFICANTLY MORE R&D SPENDING

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